Letters to the Editor

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LOW ENERGY SCATTERING OF ELECTRON BY HELIUM ATOM BY THE VARIATIONAL METHOD

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The elastic scattering cross section of electrons by helium is being investigated for such low energy of the incident electron when only S-wave phase shift needs to be considered. We apply the variation method of Hulthen with an open shell wave function and with a polarization term in the potential to take into account the distortion of the helium charge cloud due to the presence of the incident electron. Further the exchange effect due to the indistinguishability of the electrons has been included.

The system of helium atom and the incident electron satisfies the wave equation

$$(H-E)\psi(r_1, r_2, r_3) = 0 \qquad \ldots (1)$$

where H is the total Hamiltonian and E the energy of the system, r_1, r_2 and r_3 are the distances of the electrons from the nucleus. To include exchange effect we choose ψ in the following way

$$\psi(r_1, r_2, r_3) = \psi_0(r_1, r_2)\, F(r_3)\, \frac{1}{\sqrt{2}}\, (\alpha_1\beta_2 - \alpha_2\beta_1)\alpha_3$$

$$+\psi_0(r_2, r_3)\, F(r_1)\, \frac{1}{\sqrt{2}}\, (\alpha_2\beta_3\alpha - {}_3\beta_2)\alpha_1$$

$$+\psi_0(r_3, r_1)\, F(r_2)\, \frac{1}{\sqrt{2}}\, (\alpha_3\beta_1 - \alpha_1\beta_3)\alpha_2 \qquad \ldots (2)$$

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where α's and β's are the spin functions in the usual notation $F(r)$ is the wave function of the free electron and ψ_0 is the ground state wave function of the helium atom which is taken as (cf. Shull and Löwdin, 1956).

$$\psi_0(r_1, r_2) = .708991 a_0^{-3/2} \left[e^{-2.1832 \frac{r_1}{a_0} - 1.1886 \frac{r_2}{a_0}} + e^{-1.1886 \frac{r_1}{a_0} - 2.1832 \frac{r_2}{a_0}} \right].$$

a_0, being the Bohr-radius.

Substituting expression (2) for ψ in (1), multiplying by $\frac{1}{\sqrt{2}} (\alpha_1\beta_2 - \alpha_2\beta_1)\alpha_3$ $\psi_0(r_1, r_2)$, summing over the spin co-ordinates and integrating with respect to r_1 and r_2 (Mukherjee and Sil, 1962) we get an integro-differential equation for $F(r_3)$.

We have obtained from the above equation the S-wave phase-shift by the variational method of Hulthen (1944) adopted by Moiseiwitsch (1953) for a similar calculation with a different wave function and without the polarisation term. To include the long range polarisation effect the direct interaction term has been modified as in the work of Williamson and McDowell (1965) by the addition of a polarisation potential $-\frac{\alpha(r)}{r^4}$ where $\alpha(r)$ as given by Bethe (1943) has the following properties :

$$\alpha(r) \underset{r \to \infty}{\to} \alpha = 1.32 a^3_0 \; ; \; \alpha(r) \underset{r \to 0}{\to} \beta r^6 + O(r^7)$$

The calculated value of the S-wave phase shift at 13.6 ev incident electron energy is 2.108 radians whereas the corresponding theoretical value of Williamson and McDowell who solved the coupled integro-differential equation numerically is 1.963 radians. Further work is in progress.

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